Seed of Might Color Correction Process

v1.3

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Purpose

For years, people having been trying to color correct Dragon Ball, Dragon Ball Z, Dragon Ball GT, and the movies. During this time, there have been very few publicly known corrections that attempted to fix individual frames or video clips under five minutes long. Seed of Might has spent over a full year color correcting all “classic” episodes and movies in the Dragon Ball franchise. Many people have asked questions such as “What is your process?” or “What sources are you referencing?” This document aims to answer those questions in a way that someone completely unfamiliar with editing or color correcting can understand.

Before the color correction methods and references of this project are discussed, it is important to have an understanding of how color can be described and measured objectively.

The Language of Color

Understanding RGB and Digital Color

Many people know that digital screens are created by combining three primary colors of light; Red, Green, and Blue (hence RGB). The intensity of each color is measured between 0 and 255.[1] Therefore, we can describe every color with a red, green, and blue value. For example, 255, 0, 0 has a maximum red value with no green or blue, and ***looks like this red***. A value of 0, 0, 255 ***looks like this blue***. We can combine these values in different ways to create over 16 million combinations. The values 240, 240, 0 end up ***looking like this yellow***. When all values are equal, the result is a greyscale, with 0, 0, 0 being black and 255, 255, 255 being white.

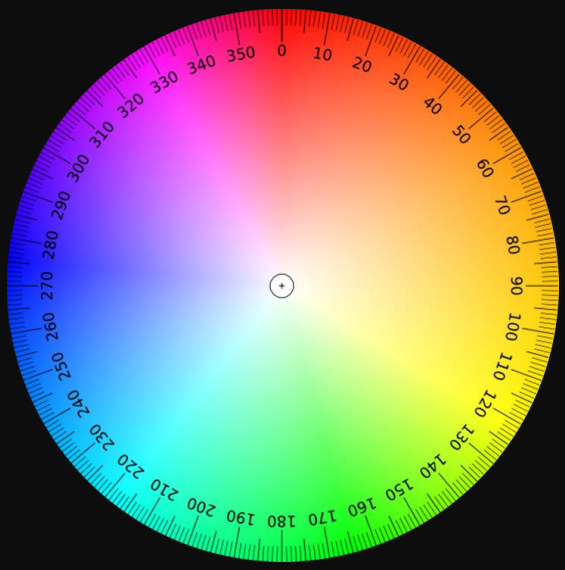
While this is simple to understand, it can be hard for humans to really visualize what some colors might look like based on these three numbers alone. If you were given the RGB values of two colors; 219, 86, 16 and 138, 45, 3 you likely would have trouble visualizing what

[1] This value is for eight-bit displays and color space. If we had access to all the original film negatives of Dragon Ball, we could scan them in 10-bit HDR, but we are limited to the sources actually available to the public. The range of values come from $2^8 = 256$ different options, where we start counting from 0.

they look like. You may conclude that they must look very different since all three numbers are different. In reality, the first set ***looks like this*** and the second ***like this***, a lighter and darker shade of orange. RGB is not a convenient language to describe color for the purposes of our color correction methods, so a different language should be chosen instead.

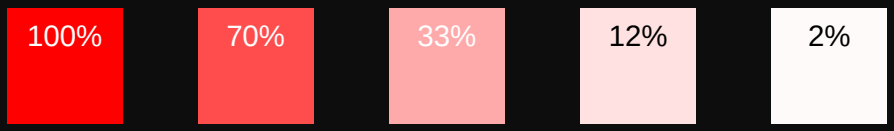
Hue, Saturation, and Brightness

Another way we can describe color is by measuring the Hue, Saturation, and Brightness (HSB)[2]. The hue value is measured in degrees like a circle; values range from 0° to 359°. It makes intuitive sense to think of hue values as a color wheel.



In this instance, the 0° color is pure red.[3] Unlike the RGB system where bigger numbers result in brighter colors, it is important to note that these colors “wrap around”. A measurement of 12° and 14° will be as similar to each other as a measurement of 1° and 359°.

The saturation value measures the richness or colorfulness of the color. Low saturation means the color is close to white or grey while a high saturation is more vivid. We measure this from 0% to 100%. Here are some examples of different saturation levels:



[2] Sometimes called “Hue, Saturation, and Value” or HSV
[3] This matches a tool we used, Just Color Picker, which can be found here https://annystudio.com/software/colorpicker/

Brightness is a measure of how light a color is. Like saturation, this is measured from 0% to 100%. Here are some examples of different brightness levels:

Like RGB, HSB can be represented in three numbers, and like different languages, we can translate between them. For example, ***this color*** can be described in RGB as 100, 161, 255 or in HSB as 216°, 61%, 100%. Once someone generally knows what hue degree values correspond to certain colors, HSV can be more intuitive in terms of viewing and understanding colors. If a color is listed as: “0°, 100%, 70%” you can understand it as ***this somewhat dark red that is still fully saturated***. This color system can be used to measure the colors of Dragon Ball and determine how accurate attempts at color correction are.

The Colors of Dragon Ball

Should Dragon Ball Look Like the Dragon Box?

Anyone invested enough in Dragon Ball likely already knows about the issues with home releases of the series. Most infamously, the Orange Bricks release is known for an excessive crop and over-saturated colors that create an image that looks like “watercolors”. When the Dragon Boxes were seen in America, they were considered to be an improvement in all factors. Combining this with the fact that the Dragon Boxes were a limited release in the US and now sell for hundreds or thousands of dollars on eBay, they have acquired something of a legendary status. Due to this, one might ask “Why are you all bothering with a color correction if the Dragon Boxes are the way the show was meant to be seen?” Even Kanzenshuu has blog posts such as this:

> FUNimation has certainly received a generational-copy of “the” Dragon Box masters, but a 2nd or 3rd generational modern copy of a careful remastering is in a completely different league than a 5th or 6th generational copy from fifteen years ago.
>
> In terms of previous FUNimation releases of the series, the Dragon Box “wins” by leaps and bounds:
>
> 
>
> *(image courtesy of Tanooki Kuribo; click through for full-size lossless PNG)*
>
> FUNimation’s first masters were much closer to their true selves, but heavily pushed toward the blue spectrum; greens became blues, while blues themselves became blacks. The “orange bricks” blurred and smoothed away the details and pushed the saturation even further. The Dragon Box master restores the original color scheme and full detail in all areas without compromise.
>
> The slightest dip in visual fidelity from the Japanese releases is almost negligible. Certain absurdly hardcore and enthusiastic fans may bring a valid argument to the table that the colors are not necessarily 100% accurate to the original productions from 1989, but for all intents and purposes, *this is how the show is supposed to look.*

[4]

A significant amount of what you’re reading above is not true. These kinds of things create misinformation which leads to confusion. Fortunately, years later, fans realized the “green skies and salmon skin” of the Dragon Boxes were not correct.

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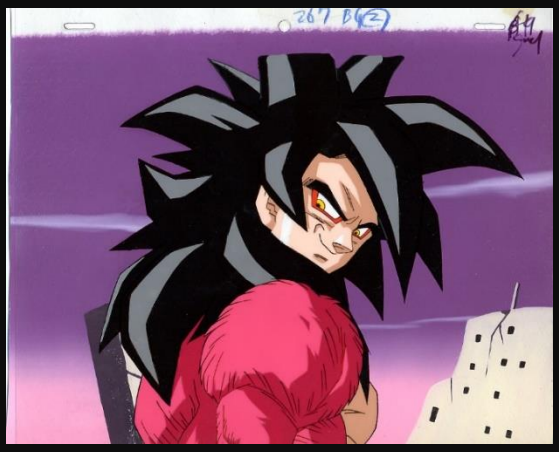
[4] https://www.kanzenshuu.com/reviews/funimation-dragon-box-z-dbz-tv-volume-1/

Sources Referenced

The primary reference source for colors are images and scans of original animation cels. When Dragon Ball was animated, the characters were drawn on transparent celluloid (hence, *cel*) placed over a matte background. Some of these cels and backgrounds have been collected by fans and shared online.





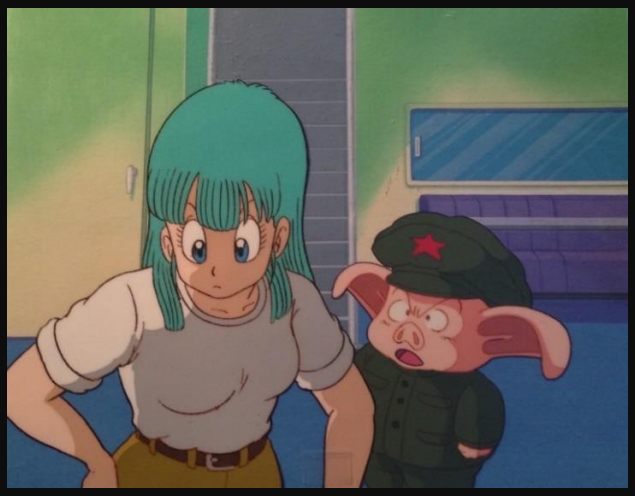



The cels provide a value for what the hue of certain characters or backgrounds should be. However, even for the same character there can be variances. See examples here:




Here are four scans of Goku. Just by a visual check, we can tell his skin looks a little different in each cel. Starting from the top left, the hue range of the lightest part of his skin goes from 17 to 20 degrees. To the right, the same light part of skin ranges from 4 to 10 degrees. The bottom left picture has a light skin range from 27 to 29 degrees, and the final picture has the same light skin going from 11 to 14 degrees.

To make matters worse, we don't have a full collection of all animation cels for all scenes, and even when we do find publicly available images, some cels look awful in terms of colors:



At this point, we are left with a decision to make:

1. Force every scene to perfectly match the cels we can find publicly. This will create an inconsistent image between scenes. For scenes with poor cel references we would tamper with the brightness and outlines of characters in pursuit of looking like those cels.
2. Determine which cels represent each character best, and create an average range of values for each color. This reference will be used to guide the color correction process for scenes without good cel references.

We decided to go with the second option. Each character has a small range of degrees for their colored components. A small deviation in hues between scenes or between episodes still allows for a consistent viewing experience. These are three examples of some hues that we would consider acceptable for Goku's skin:

12°	15°	18°

This range of hues would be considered perfectly normal to see within a single frame of animation. This range allowed us to modify characters in a way that made them look consistent throughout the series without greatly slowing down the process by forcing everything to match a single specific hue value.

Sources Not Used

There are certain types of promotional images posted by Toei. These are used to advertise Dragon Ball or serve as thumbnails of episodes on modern websites. These are examples of some promotional images:



While these images can be subjectively nice looking to some people, they don't align with the known accurate colors of the original reference material. The colors are graded differently than the original intention of the cels. There is also an inconsistency which can be seen in the almost magenta colors of adult Goku compared to the yellow tone of baby Goku. One final note about these promotional images, it is possible *some* of our color corrected footage will look like these images for *some* colors, but we did not intentionally alter our footage to match these images.

Color Correcting Process

Hue Shifting

The primary means of how we corrected the colors of this series is known as “hue shifting”. If an uncorrected Goku has a skin hue of 5° but we want it to be 15°, think of it as “shifting the colors 10 degrees higher”. Let’s walk through an example using DaVinci Resolve[5]. Say we start with this picture here which has the raw untouched colors of the Dragon Box:

Across different references, we determined a hue of about 204° is good for the sky on earth. In this photo, the sky here has a hue of about 147°. Therefore, we can raise the hue value of the image by 57°. This is the result from doing that:

The sky looks fine but the rest of the image does not.

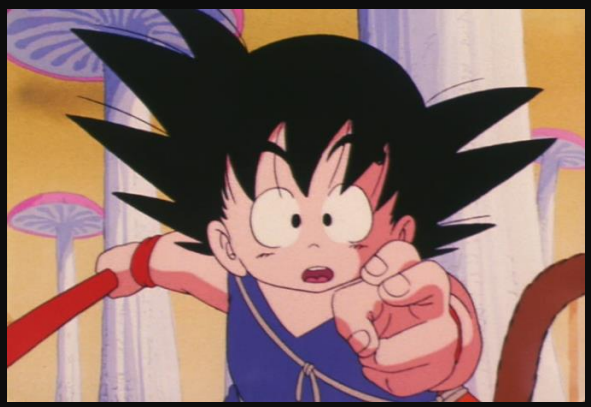
[5] These examples are created for the purpose of this document to make the process understandable. Nothing here is a perfect recreation of what the final video product looks like. This extends to all other images in the document.

Instead of shifting the hue of the entire image, we can shift some hues by different amounts. This is one result of a more precise hue shifting:

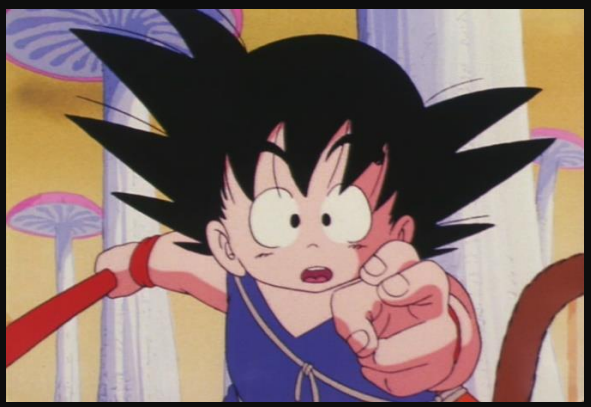
This example is much better looking but still flawed. Hue shifting alone will not remove the yellow tint from Goku's eyes. If we want to remove the tints, we must first do something known as "White Balancing".

White Balancing

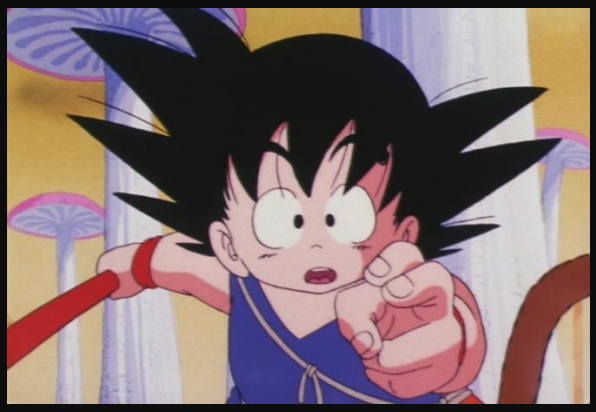
White Balancing is the process of making sure the white parts of your image actually look white. There is also "Black Balancing", which means ensuring the black parts of your image actually look black. For the sake of simplicity, the term "White Balancing" will refer to balancing both the black and white parts of an image here. In animation, this can be relatively easy to achieve; we know Goku and most characters have white eyes and we know which characters have black hair or other black features. Just like with hue shifting, we can use objective measurements to determine how well an image is white balanced. The Saturation value of an HSB number can be used to understand how much tint an image has. The lower the saturation percentage, the less tint there is and therefore the better the white balancing is. Here are a few examples of how different levels of balance can make an image look:



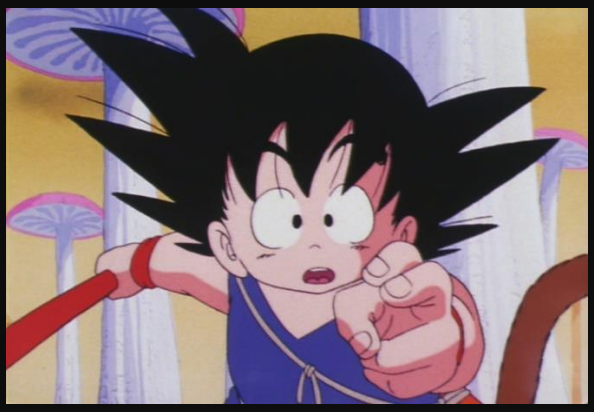
Whites 17%, Blacks 22% (RAW)



Whites 10%, Blacks 17%



Whites 4%, Blacks 10%



Whites 1%, Blacks 5%

A properly balanced image alone, without hue shifting, creates an already significant improvement for Dragon Ball. In this example, the white balance is measured in Goku's white eyes and his black hair. While 0% saturation is a perfect white balance, our goal has never been to achieve 0% saturation across the entirety of the series. Due to film grain and the way the film is scanned, saturation can change not only from one frame to the next, it can vary from one side of a single frame to another side. Instead, the goal is to get the saturations as low as reasonably possible. Generally speaking, tints at or below 5% in white areas and below 20% in black[6] areas will look nice. This makes for an incredibly handy metric to measure how good a color correction attempt is. If one person creates an image with 4% tints on white and 15% on black, and a second person creates an image with 8% tints on white and 29% tints on black, you now have an objective measurement to show the first person's color correction is at least more properly balanced.

There can be some nuances with trying to achieve the lowest tint percentages. An artifact known as "chroma bleeding" is inherent to the video source. In certain shots where a character's face is small or far away, the color from their face can bleed into the eyes. Human characters might have a little bit of a pink tint around their eyes while Piccolo's eyes may look a little green. In these cases, we try our best to measure and balance from the center of a white area and accept a small amount of tint on the edges for the sake of overall color correctness.

[6] Black areas tend to fluctuate more in terms of tint. For really black areas with a brightness below 5%, even high saturations above 40% can look fine.

Putting it All Together

By combining the white balancing and hue shifting processes, we're able to fully color correct video footage to a high standard. We determined the best way to do this was to white balance the video first, and then apply hue shifts. White balancing created a more consistent image which expedited the time it took for proper hue shifting in each episode. White balancing was an extensive process, with every single shot[7] in the series being looked at and white balanced by a human (often more than one). There are over 500 episodes worked on, each with over 200 different shots which made this process take as long as it did. While more automated attempts have been tried in an effort to reduce the time this would take, any results achieved by scripting or Artificial Intelligence, while sometimes better than the raw image, remain inferior compared to actual human review that allowed us to tweak parts of episodes as needed.

Here's a final example of everything coming together using an earlier picture:

Original

White Balance Only

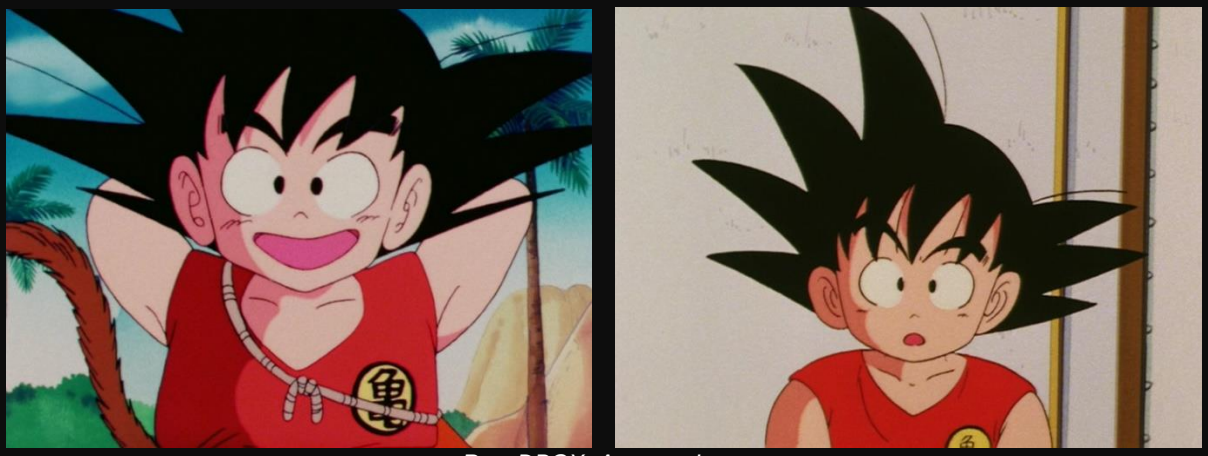
Hue Shift Only

White Balance and Hue Shift

[7] A "shot" is different than "scene" and typically constitutes a smaller amount of time. Two characters battling each other can be considered one fight scene, but a close-up of one person's face is one shot and when the image changes to a close-up of the other character's face, that is a different shot.

Removing the Bleach

In addition to white balancing and color correcting, certain shots were corrected that had a “bleached” look to them. Some episodes are worse than others. Take a look at two random raw shots from Dragon Ball:



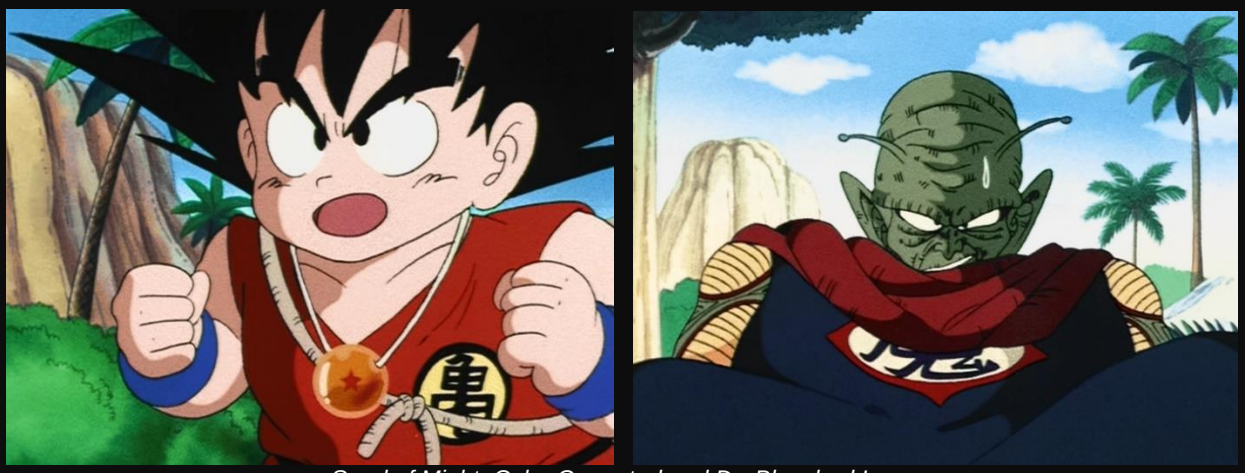
Raw DBOX, Average Images

These two frames show what an average episode of Dragon Ball usually looks like. Compare that to two other bleached examples, also raw images from the Dragon Ball Dragon Box:

Raw DBOX, Bleached Images

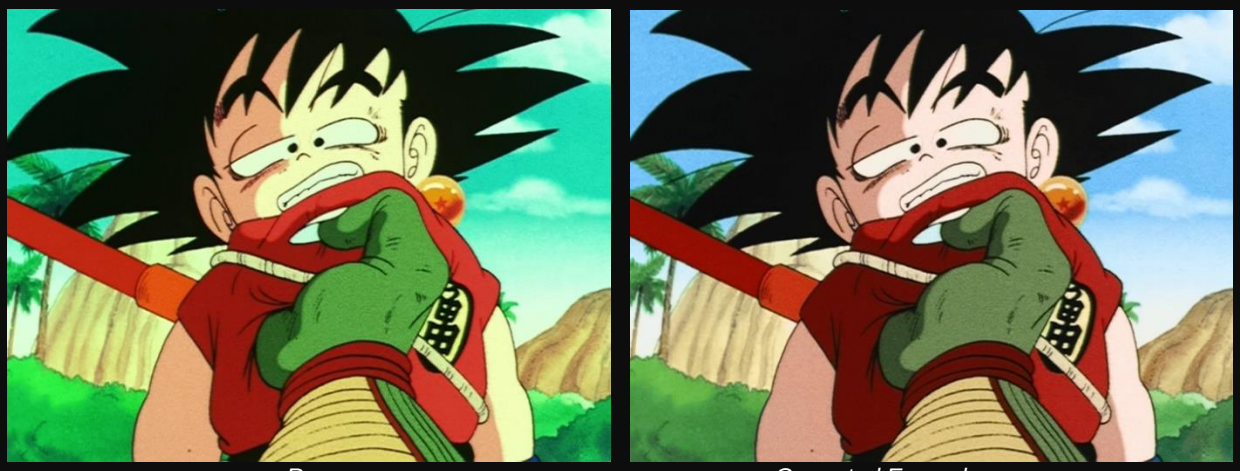
The bleached images tend to look brighter and more heavily tinted. This was likely due to a result of a poorly calibrated scanner that scanned the film too brightly, resulting in overexposure of the image.

When these scenes were identified, careful consideration was made to “de-bleach” the image. Here are a few examples created for the purpose of demonstration:



Seed of Might, Color Corrected and De-Bleached Images

Along with color correction and white balancing, the de-bleaching process makes the image look nicer and more like what would be expected from a good film scan. An interesting comparison can be made between a raw bleached image and our de-bleached output:



Raw *Corrected Example*

Clearly, the example created on the right is much nicer looking than the raw image. Objectively, our output has lower brightness and saturation levels than the raw image. Younger fans of the series may have grown up watching the infamous Orange Bricks DVDs, which tend to look brighter and more heavily saturated than the Dragon Boxes or even the DVD Singles. These fans may often see an image that is not as bold and colorful as what they grew up watching, and immediately dismiss it as wrong or inferior. However, it should now be apparent from these examples that brighter and more colorful images don't always look nicer, nor are they a more accurate representation of the original production.

Other Notes

Preservation of “Errors”

Some issues we generally avoided trying to “fix” are animation and cel errors. For example, there are certain shots where Goku’s undershirt was not colored properly or his power pole changed from red to orange. In instances like these, we referenced official releases besides the Dragon Boxes such as older DVDs or occasionally broadcast VHS recording of when the shows originally aired in Japan. These other sources confirmed certain issues are not exclusive to the Dragon Boxes, but are part of the animation of the show itself.

Accuracy vs. Subjective Preference

The color correction process has resulted in a wide range of opinions and reactions. Our goal has always been achieving the greatest possible accuracy in color correcting footage to what it would have originally looked like when first created. That being said, Dragon Ball fans come from a wide range of ages, cultures, and tastes. Most know that the broadcast audio of Dragon Ball is of a higher quality than the official optical audio on home releases, but there are still people who prefer the lower quality optical audio. There are probably some people who like the look of the Orange Bricks despite their flaws.

Ultimately, it is impossible for us to create something that will appeal to everyone’s subjective preferences. Typically, younger fans prefer brighter and more saturated colors that are more common in modern digital cartoons, rather than Japanese anime of the 80s and 90s. Others have asked for a black and white image because it reminds them of the original manga. Fans are free to edit, remix, and modify what we’ve created to meet their own personal preferences.

Credits Section

Abbreviations:
CC = Color Correction, WB = White Balance, QC = Quality Control, DB = De-Bleaching

Seed of Might is extremely thankful to all those who worked on Dragon Ball, Dragon Ball Z, Dragon Ball GT, and the movies.

321GameTime – WB

A_Regular_Old_User - WB

Adam – WB, QC

Ajay – Consulting

Atomic_XFire – CC, WB, QC

Butler – WB, Subtitles Coloring

Chicanobatman – WB

DAN – WB, QC

Davathan – WB, QC

Deli - WB

Feeso – WB

FrostyGrayBob – WB

Gaspar - WB

Hikari – WB, QC

HRSM – WB, QC

iKaos – WB, QC, Subtitles Coloring

Juan Peace – WB, QC

Jysze – CC, WB, QC, DB, Video Encoding

KameZ – CC, WB, QC

Kurayami – CC, WB, QC, DB

LastSilmaril – WB

M.M - WB

Nemu – Consulting

NoamV – WB

OhGopL’d - WB

Quazza – CC, QC, DB, Film Reference

Romao – CC, QC, DB

Ronin559 – WB

Seru – WB, WC

SpeedyBoi – CC, WB

SSGodNo78 - WB

Super Saiyan Pan – WB, QC

Tarranium – WB

TheMrDoggo – CC, WB, QC

Tokimeku Panic – WB, QC

Vanner64 – Organization, Document Author, CC, WB, QC

VDenter – CC, WB, QC

XXXBlackDrago - WB

YC61 - WB